6.0 How Does IWEM Calculate LCTVs and Make Liner Recommendations?

The objective of the ground-water fate and transport model is to determine the amount of dilution and attenuation a constituent may undergo as it migrates from a WMU to a ground-water well and determine the constituent concentration at the well. For Tier 1, once the amount of dilution and attenuation is determined, that data are used in conjunction with RGCs (either drinking water MCLs or HBNs which reflect a constituent's toxicity) to establish the maximum allowable leachate constituent concentrations for wastes that can be protectively managed in a particular unit design. We refer to these maximum allowable leachate concentrations as LCTVs. For Tier 2, the amount of dilution and attenuation help determine an exposure concentration that can be compared to RGCs. The dilution and attenuation also may be used to estimate an LCTV in Tier 2. This section describes the methods we used to develop the basis for the liner recommendations for the Tier 1 and Tier 2 analysis in IWEM.

6.1 Determining Liner Recommendations Corresponding to a 90th Percentile Exposure Concentration

Every single realization of EPACMTP in the Monte Carlo process results in a predicted concentration at the modeled ground-water well. Because the predicted ground-water concentrations are compared against health-based RGC's which reflect specific exposure duration assumptions (see Section 5), the ground-water concentrations calculated in IWEM represent time-averaged values, as depicted conceptually in Figure 6.1.

Depending on the type of RGC, the IWEM tool uses different averaging times in calculating ground-water well concentrations, as follows:

- MCL: Peak ground-water well concentration
- Non-cancer HBN: Maximum 7-year average well concentration
- Cancer HBN: Maximum 30-year average well concentration

At the conclusion of a Monte Carlo simulation consisting of 10,000 realizations, the 10,000 values of predicted ground-water concentration for each specific averaging time period are sorted from low to high into a CDF function, see Figure 6.2. In Tier 1, the CDF represents the range in expected ground-water concentrations due to nationwide variations in site hydrogeologic and other conditions; in Tier 2, the CDF represents the

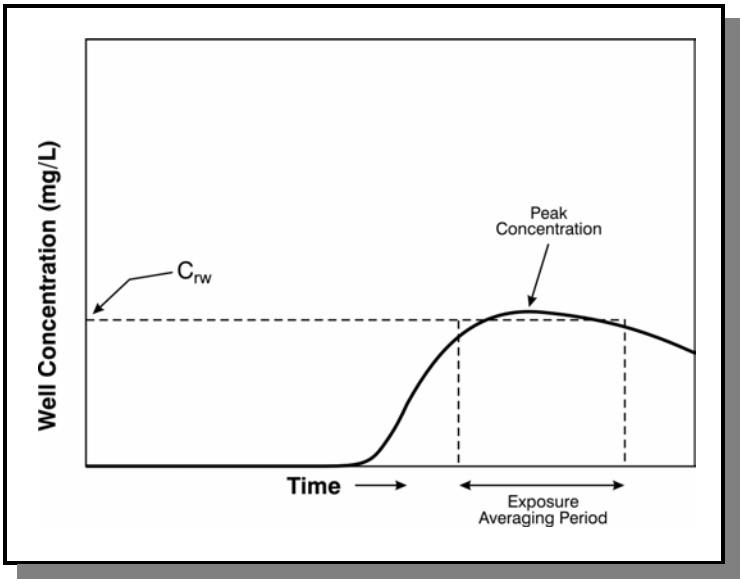

Figure 6.1 Determination of Time-Averaged Ground-Water Well Concentration.

range in the expected location-specific ground-water concentration due to uncertainty and variability in the local conditions.

For the development of the IWEM tool we selected the 90th percentile of the predicted ground-water concentration CDF as the basis for determining the Tier 1 LCTVs and as the point of comparison for the Tier 2 analysis. We based the selection of a 90th percentile protection level on: (1) the need to have a large degree of confidence that the results are adequately protective of human health and the environment given the degree of uncertainty inherent in the data and the analyses; and (2) the need to choose a level of protection that is consistent with EPA's *Guidance for Risk Characterization* (U.S. EPA, 1995b). The Tier 1 and Tier 2 evaluations are based on a high-end risk assessment which is used to describe the risk or hazard for individuals in small, but definable segments of the population. EPA's *Guidance for Risk Characterization* (U.S. EPA, 1995b) advises that "conceptually, high-end exposure means exposure above about the 90th percentile of the population distribution, but not higher than the individual in the population who has the highest exposure." Use of the 90th percentile protection level in IWEM implies that, of the modeled scenarios, 90% result in well concentrations that are lower than the specified RGC, and thus, are considered protective for at least 90% of the cases.

By definition, the LCTV is that value of leachate concentration for which the 90th percentile of the predicted ground-water well concentration is equal to the RGC. In the

case of organic constituents, the well concentration is linearly proportional to the leachate concentration input value. We used this relationship to facilitate the determination of LCTVs. For metals constituents that are subject to nonlinear sorption processes (see Section 4.2.4), we followed a slightly different process to determine LCTVs. The methodologies for organics and metals are discussed in the following sections.

6.1.1 Calculating LCTVs for Organic Constituents

For organic constituents, the fate and transport equations solved by EPACMTP are linear, which means that the magnitude of the predicted ground-water well concentration is linearly proportional to the value of the leachate concentration. In other words, a doubling of the EPACMTP input value of leachate concentration would result in a doubling of the predicted ground-water well concentration, as long as all other model parameters stay the same. This relationship can be expressed in terms of a Dilution and Attenuation Factor (DAF):

$$DAF = \frac{C_L}{C_{RW}}$$

where:

C_{RW} = Ground-water well concentration (mg/L)
C_L = Leachate concentration (mg/L)
DAF = Dilution and attenuation factor (dimensionless)

Because both the leachate concentration and the well concentration can vary with time, the calculation of DAF uses the maximum value of a constituent's leachate concentration, that is, the initial concentration at the time when leaching from the WMU begins, and uses the maximum time-average well exposure concentration (see Figure 6.1 for C_{RW}.

The DAF accounts for the aggregate effects of all fate and transport processes simulated by EPACMTP. The value of the DAF is constituent-specific, as well as WMU- and liner design-specific, that is, more protective liner designs increase the value of the DAF for a given chemical constituent. Likewise, constituents which are subject to degradation and sorption in the subsurface will have higher DAFs than constituents which do not react in the subsurface.

For the purpose of determining IWEM LCTVs, the IWEM tool first converts the CDF of predicted ground-water well concentrations into an equivalent CDF of DAF values. This is depicted schematically in Figure 6.2. The 90th percentile DAF is the DAF value that corresponds to the 90th percentile value of the ground-water well concentration

for a fixed value of leachate concentration. Because the DAF is inversely related to the ground-water well concentration, a lower DAF value indicates that the concentration at the well is closer to the leachate concentration and this provides a higher degree of protection. As depicted in Figure 6.2, the CDF of DAF is ordered from high to low values, and the 90th percentile DAF is defined such that 90% of DAF values are higher than this threshold.

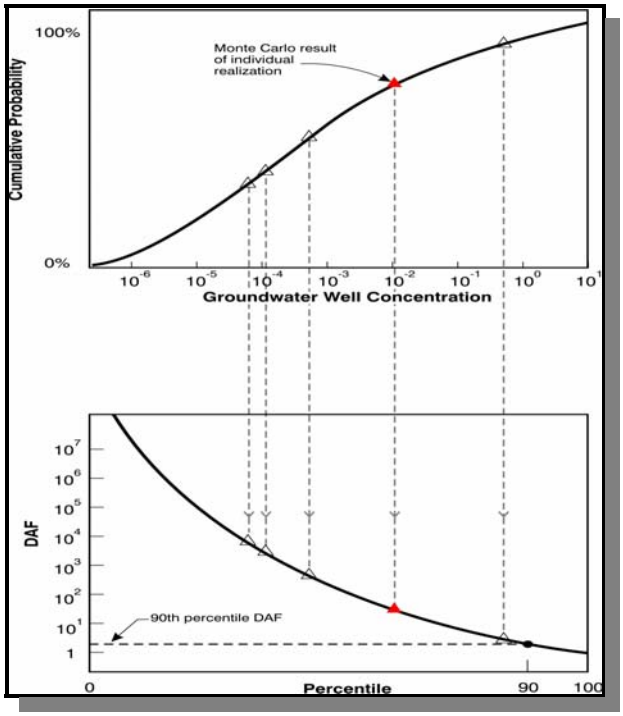

Figure 6.2 Relationship Between Cumulative Distribution Function (CDF) of Well Concentrations and Dilution and Attenuation Factors (DAFs).

Because the RGCs represent acceptable threshold values for the concentration of chemical constituents in ground water, the RGC can be substituted for C_{RW} in the equation above. In this case, C_L then represents the allowable concentration in the leachate, or the LCTV. Making these substitutions and rearranging to solve for the LCTV gives us:

$$LCTV = DAF_{90} \times RGC$$

where

$LCTV$ = Leachate Concentration Threshold Value (mg/L)
DAF_{90} = Dilution and attenuation factor at a 90th percentile protection level
RGC = Reference ground-water concentration (mg/L)

For each organic constituent in Tier 1, we conducted one modeling run (consisting of 10,000 realizations) per WMU and liner scenario to determine the DAF_{90}, and then used the equation above to calculate the Tier 1 LCTV. As we will discuss in Section 6.2, these "raw" Tier 1 LCTVs were then subjected to several caps to determine the final Tier 1 LCTVs. The final LCTVs presented in the Tier 1 look-up tables were rounded to two significant digits. For organic constituents, the Tier 1 LCTV tables in Appendix F include the DAF values generated by EPACMTP.

In Tier 2, once all of the user-specified inputs have been entered, and the Monte Carlo simulations are complete, the IWEM software constructs the CDFs of the ground-water well concentration and the DAF, and then develops a liner recommendation by directly comparing expected exposure concentrations to RGCs. In addition, IWEM calculates Tier 2 LCTVs using the same equation and caps as used for Tier 1.

6.1.2 Determining LCTVs for Metals

In the case of metals constituent whose geochemical behavior is characterized by nonlinear sorption isotherms (see Section 4.2.4), the concept of a DAF is still applicable, but due to their nonlinear transport behavior, the metals do not have a DAF that is constant across all leachate concentrations. Therefore, for metals, we used a slightly different methodology to determine the Tier 1 LCTVs. For each metal constituent and WMU/liner scenario, we ran multiple EPACMTP Monte Carlo simulations using a number of different input values of leachate concentration. For each value of leachate concentration we compared the 90th percentile value of the predicted well concentration to each of the applicable RGCs until we found the leachate concentration that resulted in 10% of the simulations exceeding the given RGC – a protection level of 90%. In this way, we determined the Tier 1 LCTVs for metals directly, without the intermediate step of determining the DAF. For this reason, DAF values are not presented for the metals in the Tier 1 Look-up Tables (Appendix F) in the results of the IWEM software.

For each metal constituent and WMU/liner scenario, we continued the iterative process of running EPACMTP with different values of leachate concentration, until we found the leachate concentration value for which the predicted ground-water concentration would match the target RGC between 89.9 and 90.1 percentile probability, i.e., we used a convergence tolerance of $\pm$ 0.1 percentile point. We then rounded this convergent input leachate concentration to two significant digits and reported it as the

LCTV of the metal constituent for the specified liner scenario. As a quality control check on these calculations, we performed an independent Monte Carlo simulation for each metal LCTV, with the above value as input, and verified that the 90th percentile of the predicted ground-water well concentrations did indeed match the target RGC, up to the first two significant digits.

In Tier 2, the LCTV for metal constituents is an estimated value. Rather than performing time-consuming iterative EPACMTP Monte Carlo simulations to determine exact LCTVs, IWEM estimates values using an empirical adjustment factor of 0.85 in order to ensure adequate protection of ground water. Tier 2 LCTVs for metals are calculated as:

$$LCTV = DAF \times RGC \times 0.85$$

6.2 Capping the LCTVs

Once the raw LCTV was determined for each constituent, this value was then subjected to the following limits:

- Toxic hydrolysis transformation products cap;
- 1,000 (mg/L) cap; and
- TC Rule cap.

6.2.1 Hydrolysis Transformation Products

For organic constituents with transformation products that are produced by chemical hydrolysis, the final LCTV values of the parent are modified if necessary to be protective for the daughter product(s). That is, we also calculated LCTVs for any transformation product(s) into which the parent might hydrolyze, assuming complete transformation. Then, if any of the daughter products was found to have a lower LCTV than the parent, the parent LCTV was set equal to (that is, capped at) the LCTV of the daughter. Details of the calculation procedure we used to develop the daughter product caps are presented in the text box which follows this page.

Table 6.1 presents the IWEM constituents that have toxic hydrolysis transformation products that are included in the IWEM Tier 1 and Tier 2 analyses. We assembled this table from information in Kollig et al. (1993) and Jeffers et al. (1989). The last column of Table 6.1 presents the ratio of the number of moles of the daughter product to the number of moles of the parent compound; for instance, a “1” in this column means that one mole of the daughter is produced by the hydrolysis of one mole of the parent, and a “2” in this column means that two moles of the daughter are produced by the hydrolysis of one mole of the parent compound.

In accounting for hydrolysis daughter products, we did not explicitly model the formation, fate, and transport of transformation products along with the parent constituent in the EPACMTP simulations, but rather made the adjustments by applying a cap to the parent LCTV if necessary. This methodology is relatively simple and protective because it is based on the assumption that the parent compounds are fully transformed. In reality, the rate of hydrolysis may be quite slow with half-lives on the order of several hundred years, and the formation of certain daughter products may also depend on pH and other factors. When we calculated the parent LCTVs for slowly hydrolyzing compounds we used the actual, constituent-specific hydrolysis parameters (see Appendix B). Only when we calculated the daughter LCTVs did we assume that 100% transformation would occur.

Calculation Procedure to Determine Daughter Product Caps

Suppose that we have a parent chemical (P) that hydrolyzes to form two daughter products (D1 and D2). The molecular weights of these chemicals are MW(P), MW(D1), and MW(D2). The EPACMTP-modeled DAFs are DAF(P), DAF(1), and DAF(2). The reference ground-water concentrations for these chemicals are RGC(P), RGC(D1), and RGC(D2). The "raw" LCTVs are calculated as the product of the modeled DAF and the given RGC; these values are denoted as LCTV(P), LCTV(D1) and LCTV(D2) and are referred to as "raw" LCTVs because they are the calculated values that have not yet been affected by the capping procedure. One mole of P hydrolyzes to form n(1) moles of D(1) and n(2) moles of D(2); n(1) and n(2) are referred to as the stoichiometric factors.

For a given RGC (reference ground-water concentration, e.g., MCL, HBN), the following steps are followed to calculate the final LCTV of the parent compound:

1. Determine the raw LCTV of the parent chemical, using the following equation:

$$LCTV(P) = DAF(P) \times RGC(P)$$

2. Determine the (raw) LCTV of each daughter, using the following equations:

$$LCTV(D1) = DAF(D1) \times RGC(D1)$$
$$LCTV(D2) = DAF(D2) \times RGC(D2)$$

3. Using the molecular weight and stoichiometric factor of each daughter, calculate the adjusted LCTV (denoted as LCTV(P(i)*) in the equations below) of the parent based on each daughter.

For D1:
$$LCTV(P(D1)^*) = LCTV(D1) \times MW(P) / (n(D1) \times MW(D1))$$
For D2:
$$LCTV(P(D2)^*) = LCTV(D2) \times MW(P) / (n(D2) \times MW(D2))$$

4. For each daughter, compare the adjusted LCTV of the parent based on that daughter to the uncapped LCTV of the parent; if the adjusted LCTV of the parent is less than the uncapped LCTV of the parent, replace the uncapped LCTV of the parent with the adjusted LCTV of the parent based on that daughter:

For D1:
If $(LCTV(P) < LCTV(D1) \times MW(P) / (n(D1) \times MW(D1))$
then $LCTV(P(D1)^*) = LCTV(D1) \times MW(P) / (n(D1) \times MW(D1))$

Otherwise $LCTV(P(D1)^*) = LCTV(P)$

For D2:
If $(LCTV(P) < LCTV(D2) \times MW(P) / (n(D2) \times MW(D2))$
then $LCTV(P(D2)^*) = LCTV(D2) \times MW(P) / (n(D2) \times MW(D2))$

Otherwise $LCTV(P(D2)^*) = LCTV(P)$

5. Compare all the adjusted LCTV of the parent, and pick the smallest value as the final LCTV of the parent:

$$LCTV(P) = \text{Min}\,(LCTV(P(D1)^*), LCTV(P(D2)^*))$$

Table 6.1 IWEM Constituents with Toxic Hydrolysis Transformation Products

Parent Constituent CAS #	Common Name	Transformation Product(s) CAS #	Common Name	Molar Ratio
107-13-1	Acrylonitrile	79-06-1	Acrylamide	1
		79-10-7	Acrylic Acid	1
100-44-7	Benzyl chloride	100-51-6	Benzyl alcohol	1
74-83-9	Bromomethane	67-56-1	Methanol	1
50-29-3	DDT, p,p'-	72-55-9	DDE	1
80-62-6	Methyl methacrylate	67-56-1	Methanol	1
75-09-2	Methylene Chloride (Dichloromethane)	50-00-0	Formaldehyde	1
79-34-5	Tetrachloroethane 1,1,2,2-	79-01-6	Trichloroethylene	1
71-55-6	Trichloroethane 1,1,1-	75-35-4	Dichloroethylene1,1-	1
79-00-5	Trichloroethane 1,1,2-	75-35-4	Dichloroethylene1,1-	1
75-34-3	Dichloroethane 1,1-	75-07-0 75-01-4	Acetaldehyde Vinyl chloride	1 1
107-06-2	Dichloroethane1,2-	75-01-4 75-21-8 107-21-1	Vinyl chloride Ethylene oxide Ethylene Glycol	1
111-44-4	Bis(2-chloroethyl)ether	123-91-1	Dioxane 1,4-	1
58-89-9	HCH (Lindane) gamma-	120-82-1	Trichlorobenzene 1,2,4-	1
319-84-6	HCH alpha-	120-82-1	Trichlorobenzene 1,2,4-	1
630-20-6	Tetrachloroethane 1,1,1,2-	79-01-6	Trichloroethylene	1
60-51-5	Dimethoate	7783-06-4 67-56-1	hydrogen sulfide Methanol	1 1
131-11-3	Dimethyl phthalate	67-56-1	Methanol	2
298-00-0	Methyl parathion	67-56-1 7783-06-4	Methanol hydrogen sulfide	2 1

A number of daughter products that are produced by hydrolysis of these parent compounds could not be included in the IWEM analyses due to a lack of toxicological benchmarks for the daughter compounds. Table 6.2 presents a list of these daughter products along with their IWEM parent constituents. Several parent constituents have the same hydrolysis end-products, and a number of the daughters in Table 6.2 therefore are listed with multiple parents. An example is hydrochloric acid which is a breakdown product of a several chlorinated components.

Table 6.2 IWEM Daughter Constituents Without RGC Values

Daughter Constituent		IWEM Parent Constituent	
CAS No.	**Name**	**CAS No.**	**Name**
64-19-7	Acetic acid	71-55-6	Trichloroethane, 1,1,1-
7664-41-7	Ammonia	107-13-1	Acrylonitrile
111-46-6	Bis(2-hydroxyethyl)ether	111-44-4	Bis(2-chloroethyl)ether
107-20-0	Chloroacetaldehyde	79-00-5	Trichloroethane, 1,1,2-
107-07-3	Chloroethanol, 2-	107-06-2	Dichloroethane
628-89-7	(2-chloroethoxy)ethanol,2-	111-44-4	Bis(2-chloroethyl)ether
7647-01-0	Hydrochloric acid	100-44-7	Benzyl chloride
		7647-01-0	DDT, p,p'-
		75-09-2	Dichloromethane
		79-34-5	Tetrachloroethane, 1,1,2,2-
		71-55-6	Trichloroethane, 1,1,1-
		79-00-5	Trichloroethane, 1,1,2-
		75-34-3	Dichloroethane, 1,1-
		107-06-2	Dichloroethane, 1,2-
		111-44-4	Bis(2-chloroethyl)ether
		58-89-9	HCH, gamma-
		319-84-6	HCH, alpha-
		630-20-6	Tetrachloroethane, 1,1,1,2-
7783-06-4	Hydrogen sulfide	630-20-6	Tetrachloroethane, 1,1,1,2-
		298-00-0	Methylparathion
		60-51-5	Dimethoate
79-14-1	Hydroxacetic acid	630-20-6	Tetrachloroethane, 1,1,1,2-
79-41-4	Methylacrylic acid	80-62-6	Methylmethacrylate
4376-18-5	Methylhydrogen phthalate	131-11-3	Dimethyl phthalate
100-02-7	Nitrophenol, 2-	298-00-0	Methylparathion
7664-38-2	Phosphoric acid	298-00-0	Methylparathion
88-99-3	Phthalic acid	131-11-3	Dimethylphthalate
87-61-6	Trichlorobenzene	58-89-9	HCH, gamma-
		319-84-6	HCH, alpha-

6.2.2 1,000 mg/L /Cap

The second cap we applied was to limit the calculated LCTV for any constituent at 1,000 mg/L. If the LCTV calculated from the ground-water modeling analysis is greater than 1,000 mg/L, the LCTV will be set to 1,000 mg/L. The basis for this cap is that leachate concentrations from nonhazardous wastes are not expected to exceed this value. The calculated "raw" LCTVs exceeded the 1,000 mg/L cap in a significant number of cases for composite liner designs. Review of the LCTV tables in Appendix F shows that many of the composite liner LCTVs are capped at this value.

6.2.3 TC Rule Cap

Finally, we capped the LCTVs for the 39 constituents that are identified in the Toxicity Characteristic Rule (TC Rule) (40 CFR 261.24; U.S. EPA, 1990) at their regulatory TC level (see Table 6.3). The basis for applying this cap is that any waste with leachate concentrations equal to or greater than the TC Rule regulatory level is a characteristically hazardous waste under RCRA and state statutes.

6.3 Making Liner Recommendations

The IWEM tool allows the user to enter chemical and facility information and automatically analyzes the results of the database query (Tier 1) or the modeling analysis (Tier 2) to determine an appropriate WMU design that is protective of ground water. The use and interpretation of the Tier 1 and Tier 2 evaluations are described in this section.

When interpreting the Tier 1 and 2 liner recommendations, **the following key risk assessment issues should be kept in mind:**

- The IWEM HBNs correspond to a target risk of 1×10^{-6} for carcinogens and a target HQ of 1 for noncarcinogens. These targets are used to calculate separate HBNs for each constituent of concern, and separate HBNs for each exposure route of concern (ingestion or inhalation). The Tier 1 and Tier 2 evaluations do not consider combined exposure from ground-water ingestion (from drinking water) and ground-water inhalation (from showering), nor do they consider the potential for additive exposure to multiple constituents. Therefore, use caution when evaluating multiple constituents that have similar fate and transport characteristics (e.g., similar k_ds and hydrolysis rates), as well as constituents with non-cancer health effects associated with the same target organ.

Table 6.3 Toxicity Characteristic Regulatory Levels (U.S. EPA, 1990)

Constituent	TC Rule Leachate Concentration Limit (mg/L)	Constituent	TC Rule Leachate Concentration Limit (mg/L)
Arsenic	5.0	Hexachlorobenzene	0.13
Barium	100	Hexachloro-1,3-butadiene	0.5
Benzene	0.5	Hexachloroethane	3.0
Cadmium	1.0	Lead	5.0
Carbon tetrachloride	0.5	Lindane	0.4
Chlordane	0.03	Mercury	0.2
Chlorobenzene	100	Methoxychlor	10.0
Chloroform	6.0	Methyl ethyl ketone	200.0
Chromium	5.0	Nitrobenzene	2.0
o-Cresol	200	Pentachlorophenol	100.0
m-Cresol	200	Pyridine	5.0
p-Cresol	200	Selenium	1.0
Cresol	200	Silver	5.0
2,4-D	10.0	Tetrachloroethylene	0.7
1,4-Dichlorobenzene	7.5	Toxaphene	0.5
1,2-Dichloroethane	0.5	Trichloroethylene	0.5
1,1-Dichloroethylene	0.7	2,4,5-Trichlorophenol	400
2,4-Dinitrotoluene	0.13	2,4,6-Trichlorophenol	2.0
Endrin	0.02	2,4,5-TP Acid (Silvex)	1.0
Heptachlor	0.008	Vinyl chloride	0.2

- Usually, doses less than the RfD (HQ=1) are not likely to be associated with adverse health effects and, therefore, are less likely to be of regulatory concern. As the frequency and/or magnitude of the exposures exceeding the RfD increase (HQ>1), the probability of adverse effects in a human population increases. However, it should not be categorically concluded that all doses below the RfD are "acceptable" (or will be risk-free) and that all doses in excess of the RfD are "unacceptable" (or will result in adverse effects).

6.3.1 Use and Interpretation of Tier 1 Evaluation

The Tier 1 evaluation is intended to provide a rapid, national-scale screening assessment to determine if a proposed WMU design will be protective of human health and the environment.

In a Tier 1 analysis, the potential impact that a WMU may have on ground-water resources is characterized by comparing the expected constituent leachate concentration (based on the TCLP or another appropriate leachate test method) to the calculated LCTV in the appropriate look-up table. That is, the Tier 1 user only needs to know the type of WMU to be evaluated, the chemical constituents expected in the waste (these constituents are chosen from a list provided in the IWEM software), and their expected leachate concentrations. EPA has performed the Tier 1 Monte Carlo simulations for each of the IWEM constituents and assembled the results into Tier 1 LCTV look-up tables. An electronic version of these look-up tables is included in the IWEM software as the Tier 1 Evaluation, and a printed copy of the tables are included in Appendix F of this document. This appendix presents LCTV values corresponding to each of the available RCGs for each constituent, that is LCTVs based on MCLs as well as on ingestion and inhalation cancer and non-cancer HBNs. Where a RGC is not available, for instance, a constituent does not have an inhalation HBN, the LCTV entry in the table is left blank. The IWEM Tier 1 evaluation automatically performs the required comparisons of leachate concentration to all of the LCTVs for each waste constituent and liner scenario. The result of this comparison determines the recommended liner system for the WMU or determines whether land application of this waste is appropriate (that is, determines whether the waste constituent concentrations will not exceed HBNs at a well if a particular WMU design is implemented). In Tier 1, the results of the evaluation are presented in terms of a MCL summary and a HBN summary. The HBNs summary reflects the liner recommendation based on the most protective, that is the lowest, HBN available for each constituent.

If the user-identified leachate concentrations for all constituents are lower than the corresponding no-liner LCTVs in the look-up table, then no liner is recommended as being sufficiently protective of ground water. If any leachate concentration is higher than the corresponding no-liner LCTV, then a minimum of a single clay liner is recommended. If any leachate concentration is higher than the corresponding single-liner LCTV, then a minimum of a composite liner is recommended. If any concentration is higher than the composite liner, consider pollution prevention, treatment, or additional controls. For waste streams with multiple constituents, the most protective minimum recommended liner that is specified for any one constituent is the recommended liner design.

After conducting a Tier 1 analysis, the user can choose to implement the Tier 1 recommendation by designing the unit based on the liner recommendations given by the IWEM software. If the user chooses to implement the Tier 1 recommendation, consultation with state authorities is recommended to ensure compliance with state regulations, which may require more protective measures than the Tier 1 lookup tables recommend. Alternatively, if the waste has one or very few "problem" constituents that call for a more stringent and costly liner system (or which make land application

inappropriate), evaluate pollution prevention, recycling, and treatment efforts for those constituents.

If, after conducting the Tier 1 analysis, the user is not satisfied with the resulting recommendations or if site-specific conditions seem likely to support the use of a liner design different from the one recommended (or suggest a different conclusion regarding the appropriateness of land application of a waste), then the user can proceed to the Tier 2 analysis or conduct a site-specific ground-water fate and transport analysis (Tier 3).

6.3.2 Use and Interpretation of Tier 2 Evaluation

The Tier 2 analysis is designed to provide user-friendly software that allows users to input location-specific data for a number of EPACMTP input parameters and quickly determine if a proposed WMU design will be protective of human health and the environment.

As with Tier 1, the IWEM software provides the Tier 2 user with a list of constituents commonly encountered when managing industrial waste, along with the opportunity to input constituent-specific data that are necessary for a Tier 2 analysis (for examples parameters such as decay rate and sorption coefficients, as well as HBNs and/or MCLs). The IWEM Tier 2 evaluation also allows the user to define new chemicals and enter the required chemical property data, including user-specified RGCs. Once the list of constituents and their chemical data have been specified, the user is requested to input location-specific data, where available, and to document the source of these data. In Tier 2, the user also selects the type of RGC to be used in the evaluation. This can be MCL, HBN, or all available. If the user selects one type of RGC, IWEM performs the evaluation only for that RGC. If all available RGCs are selected, then all are considered in the evaluation and the final liner recommendation will be based on the most protective, that is the lowest, RGC for each constituent.

After entering the available data, the EPACMTP model is automatically launched by the IWEM software. In Tier 2, EPACMTP will perform Monte Carlo simulations, comprising 10,000 model realizations for each waste constituent and liner design, in order to determine the minimum recommended liner design at a 90^{th} percentile protection level. The Monte Carlo simulations can be computationally demanding, and an evaluation of multiple liner designs for a single waste constituent can take several hours. In order to optimize the computational process, IWEM will first perform the liner evaluations from least protective (no-liner) to most protective (composite liner). If during this process, IWEM identifies a liner design that is protective for all constituents (for instance, a single clay liner), it will stop the evaluation process, and not evaluate more protective designs (in the example case, it would skip the composite liner evaluation). Once the modeling analyses are complete, the user is provided with

recommendations regarding whether or not a specific liner type for a WMU is protective based on the modeled 90th percentile exposure concentrations using the location-specific data and the RGCs for the chemicals of concern.

After conducting the Tier 2 Evaluation, you can choose to implement the Tier 2 recommendation by designing the unit based on the liner recommendations given by the IWEM software or continue to a Tier 3 analysis. If the user chooses to implement the Tier 2 recommendation, consultation with state authorities is recommended to ensure compliance with state regulations, which may require more protective measures than the Tier 2 results recommend. Alternatively, if the waste has one or very few "problem" constituents that call for a more stringent and costly liner system (or which make land application inappropriate), evaluate pollution prevention, recycling, and treatment efforts for those constituents. If you are not satisfied with the resulting recommendations or if site-specific conditions seem likely to support the use of a liner design different from the one recommended (or suggest a different conclusion regarding the appropriateness of land application of a waste), then you may wish to consider a fully site-specific ground-water fate and transport analysis (Tier 3).